PROCEEDINGS OF SPIE

# *Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023)*

**Srikanta Patnaik**
**Tao Shen**
*Editors*

**19–21 May 2023**
**Kunming, China**

*Organized by*
Kunming University of Science and Technology (China)

*Sponsored by*
Interscience Research Network (IRNet) (India)

*Published by*
SPIE

**Volume 12779**

Proceedings of SPIE 0277-786X, V. 12779



Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023), edited by Srikanta Patnaik, Tao Shen, Proc. of SPIE Vol. 12779, 1277901 · © 2023 SPIE · 0277-786X · Published under a Creative Commons Attribution CC-BY 3.0 License · doi: 10.1117/12.3000226

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:
Author(s), "Title of Paper," in *Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023)*, edited by Srikanta Patnaik, Tao Shen, Proc. of SPIE 12779, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510668072
ISBN: 9781510668089 (electronic)

Published by
**SPIE**
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time)
SPIE.org


Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE. DIGITAL LIBRARY
SPIEDigitalLibrary.org

**Paper Numbering:** A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

# Contents

**INTELLIGENT SYSTEMS**

**INTELLIGENT SENSORS AND AUTOMATION**



**MACHINE LEARNING**

**AUTOMATION CONTROL**

# Conference Committee

*General Chairs*

**Tao Shen**, Kunming University of Science and Technology (China)
**John Wang**, Montclair State University (United States)
**Simon X. Yang**, University of Guelph (Canada)

*Publication Chair*

**Srikanta Patnaik**, I.I.M.T., Bhubaneswar (India)

*Programme Chair*

**Leandros A. Maglarasc**, De Montfort University (United Kingdom)

*Organising Chairs*

**Hongbin Wang**, Kunming University of Science and Technology (China)
**Nilanjan Dey**, Techno India College of Technology (India)
**Jian Wang**, Kunming University of Science and Technology (China)
**Shoulin Yin**, Shenyang Normal University (China)
**Hang Li**, Shenyang Normal University (China)
**Mohammad Shidujaman**, Independent University (Bangladesh)

*Overseas Advisory Chairs*

**Weiwen Deng**, Beihang University (China)
**Feng Qiao**, Shenyang JianZhu University (China)

*Finance Chair*

**Silai Zhou**, IRNet China (China)

*Contacting Chair*

**Bin Hu**, Changsha Normal University (China)

*Committee Members*

**Rabi N., Mahapatra**, Texas A&M University (United States)
**Liang Zong**, Shaoyang University (China)
**Xilang Tang**, Airforce Engineering University (China)
**Arturo De La Escalera Hueso**, Universidad Carlos III de Madrid (Spain)

**Ali Hessami**, Vega Systems (United Kingdom)
**Yen-Tseng Hsu**, National Taiwan University of Science and Technology (Taiwan)
**Lakhmi C. Jain**, Bournemouth University (United Kingdom)
**Sanjay Jain**, National University of Singapore (Singapore)
**Xiaokun Yang**, University of Houston Clear Lake (China)
**V.S.S. Yadavalli**, University of Pretoria (South Africa)
**Bruno Apolloni**, Università degli Studi di Milano (Italy)
**Harry Bouwman**, Technische Universiteit Delft (Netherlands)
**Shyi-Ming Chen**, National Taiwan University of Science and Technology (Taiwan)
**Yahaya Coulibaly**, University Technology Malaysia (Malaysia)
**B.K. Das**, Government of India (India)
**Joseph Davis**, The University of Sydney (Australia)
**Guangzhi Qu**, Oakland University (United States)
**Chidananda Khatua**, Intel Corporation Inc. (United States)
**Ayse Kiper**, Middle East Technical University (Turkey)
**Ladislav J. Kohout**, Florida State University (United States)
**Reza Langari**, Texas A M University (United States)
**Maode Ma**, Nanyang Technological University (Singapore)
**N. P. Mahalik**, California State University, Fresno (United States)
**Vladicescu Popentiu, Florin**, City University (United Kingdom)

*Keynote Speakers*

**Bernard J. Jansen**, Hamad Bin Khalifa University (Qatar)
**Giuseppe Carbone**, University of Calabria (Italy)
**Simon X. Yang**, University of Guelph (Canada)

# Introduction

Automation and robotics are in at the pinnacle of innovation and development. In this era of automation and robotics, Mechatronics and Intelligent Robotics has become a prime factor throughout the globe for production, manufacturing and commercial spheres. It has been a facilitator in shaping the process of globalization through technological innovations and real-world applications by solving new challenges of the modern human life and society. The multidisciplinary approach of Mechatronics combined with Robotics help out to develop intelligent and integrated autonomous systems as a combination of elements having diverse behaviors like, multi-sensor fusion, control software, smart actuators, service applications and human–machine interaction. The principal goal of the conference is to promote research and developmental activities in Mechatronics and Intelligent Robotics by creating a platform to promote scientific information interchange between researchers, developers, engineers, students, and practitioners working all around the world. The conference will also make it an ideal platform for people to share views and experiences in Mechatronics and Intelligent Robotics and related areas.

Mechatronics and Intelligent Robotics is not a restricted area within the department of mechanical and electronics, but it is an integral part of manufacturing process in any organization. The field of Modeling and design strategies, Design solutions and developments, Innovative service tasks, Industrial applications, Sensor integration and experimental testing strategies, Intelligent control and operation strategies, wearable robots or devices are the various areas studied under Mechatronics and Intelligent Robotics. Predominantly for Mechatronics, a variety of topics like Intelligent mechatronics, robotics and bio-mimetics, Modelling and control of mechatronics systems and its elements, mechanisms of micro and Nano systems, Sensors, AI, neural networks and fuzzy logic in Mechatronics and robotics, Industrial automation, process control and networked control systems, Tele-robotics and human computer interaction, human-robot interaction are covered.

Today, for any formal or informal system to manage data gathering or to get and process the data, to interpret the data, and to provide logical judgements to decision makers as a basis for action an intelligent system is required. It contains knowledge about the domain with a refined decision-making process and the proficiency to explain its actions. The best essential feature of an intelligent system is its ability to effectually interact with humans to teach or assist complex information processing. These technologically advanced machines perceive and respond to the world around them subsequently. Ambient Intelligence, Artificial Intelligence, Automated Reasoning, Bayesian Models, Bioinspired Intelligence, Brain Modeling and Simulation, Commonsense Reasoning, Computational Intelligence, Conceptual Inference and Reasoning, Deep Learning, Evolutionary Computing, Expert Systems and Fuzzy Sets and Systems are the innumerable sub-fields in intelligent system.

Being an interdisciplinary branch of computer science and engineering now-a-days, Robots are widely used in many industries to perform a variety of tasks. The robotics field creates intelligent machines to assist humans in dissimilar possible ways taking number of distinct forms. Numerous automations are done for the tasks which are traditionally performed by human beings for design, construction and manufacturing. The Mechatronics and Artificial Intelligence combine build a better robot for performance. Though AI is not directly related to mechatronics, it has a lot of applications within mechatronics. In the field of designing and developing autonomous

machines, mechatronics is a best choice. The Robotics include Artificial Intelligence, Bio-inspired robotics, Control algorithms and control systems, Healthcare robotics, Human-Robot Interaction, Kinematics and dynamics analysis, Manufacturing robotics, Parallel robots and manipulators, Robotic cognition and emotion, Robotic perception and decision, and Sensor integration. Through Intelligent Sensors and Automation various intelligent functions are performed as a part of task or duty with an ability to self-test, self-validate and self-adapt as well as self-identify. The intelligent sensor technology, Optical and electronic sensor technology, Environmental, gas detection sensor technology, Process Industry Sensor Technology, Artificial intelligence and sensor technology, Biomedical Sensor Technology, Sensor Technology Applications, Internet in vehicles and cloud sensor technology, Sensor Material and Social robotics are the integrated fields in this area. With all these Machine leaning is such an unescapable part and application of this is almost in every ground, which includes sub areas like Action and Event Recognition, Symbolic Learning, Biometrics Recognition, Classification, Clustering, Data Mining, Deep Learning, Face and Gesture Recognition, Feature Extraction, Dimensionality Reduction, Manifold Learning, Information Retrieval, Kernel Methods, Support Vector Machines and many more that is fruitfully applied while modeling Mechatronics and Intelligent Robotics systems.

With this very broad coverage of this section, we hope the readers shall find insight.

**ACKNOWLEDGEMENTS**

We are immensely thankful to the authors for their contributions to the Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023). We are also thankful to the reviewers for contributing their time and expertise to maintain the quality of this proceeding.

We would like to thank SPIE for their support and work supporting the Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023).

We are thankful to Prof. Bernard J. Jansen of Hamad Bin Khalifa University, Qatar, Prof. Giuseppe Carbone of University of Calabria, Italy and Prof. Simon X. Yang of University of Guelph, Canada, for their enlightening keynote address.

Last but not least we are extremely thankful to Interscience Research Network (IRNet) International for organizing this conference and providing constant support and services for organizing this event.

We are confident that the readers will get immense benefit and knowledge from this published volume ***Seventh International Conference on Mechatronics and Intelligent Robotics (ICMIR 2023)***. Also, we look forward to your valued contribution and support to the next International Conference on Mechatronics and Intelligent Robotics (ICMIR 2024).

**Srikanta Patnaik**
**Tao Shen**